Longitudinal Profile

Longitudinal Profile

The longitudinal profile characterizes average stream slopes and depths of riffles, pools, runs, glides, rapids, and steps. The *average water surface slope* is required for delineating stream types and is used as a normalization parameter for developing ratios (**Figure 12**). The water surface slopes of individual bed features (facet slopes) can be compared using longitudinal profile data (e.g., riffle facet slope *vs*. pool facet slope). In addition, the longitudinal profile can be used to obtain maximum depth of individual bed features and bed feature spacing.

The *average water surface slope* is measured between two bed features of the same type (e.g., top of riffle to top of riffle) over a minimum distance of 20 to 30 bankfull channel widths. To calculate average slope, divide the change in water surface elevation by the stream length between the two features.

Longitudinal profiles require basic surveying skills and equipment. Because longitudinal profiles cover a large distance (minimum of 20 to 30 bankfull channel widths), multiple instrument setups are often required.

Longitudinal profiles are measured in the downstream direction. Typically, a 300-foot tape is laid along the centerline of the channel (not Thalweg) to obtain stream length stationing. If the flow velocity or depth does not allow the tape to be stable at the channel mid-point, then station the tape along one side of channel at low flow edge of water.

An elevation measurement and the associated distance along the tape (station) are taken at major breaks in the bed topography and generally at the start, mid-point, and end of features (e.g., start, mid-point, and end of riffle). Four types of features are measured at each station: 1. Thalweg (deepest part of channel) (THL), 2. Water Surface (WS), 3. Bankfull (BKF) (if a good indicator), and 4. Low Bank Height (LBH) (if the lowest bank height is greater than bankfull stage to indicate degree of incision). The thalweg and water surface measurements should reflect bed elevation and water surface slope changes as the stream progresses through a bed feature sequence (e.g., riffle, run, pool, glide). Note the stationing of the cross-section locations along the profile. An example profile with survey notes and a plotted profile are shown in **Table 5** and **Figure 13**.

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Longitudinal Profile Instructions

1. Setup the instrument with a clear line of sight to a benchmark. The first setup should reference (backsight) a benchmark (BM) of known elevation. Approximate the number and location of each setup needed based on potential line-of-sight limitations. The instrument should be placed at an elevation higher than the highest feature required for the survey.
2. Backsight (BS) the benchmark (place the rod on the benchmark and obtain a rod reading). Determine the height of the instrument (HI). HI = BM elevation + BS rod reading.
3. Starting at the upstream end of the reach, position a 300-foot tape along the centerline of the channel if flow permits or along edge of water to obtain stream length stationing.
4. Place the rod at the Thalweg at station 0 on the tape. Obtain the rod reading and record the value in the foresight (FS) column as shown in **Table 5**. Record water surface, bankfull, and lowest bank height measurements (if lowest bank height is greater than bankfull stage) perpendicular to the tape at station 0 as shown in **Figure 12**. (**Note:** LBH in **Figure 12** at station 0+00 is the same as BKF).
5. Continue the same sequence downstream to the start, mid-point, and end of major bed features and repeat the same measurements at the new stations.
6. At cross-section locations, note the distance (station) on the longitudinal profile tape. When using multiple instrument setups, take a measurement on top of both cross-section end points to obtain common elevations of the cross-section and longitudinal profile.
7. Profile your entire reach (20 to 30 bankfull channel widths is normally used as a minimum longitudinal profile length guideline).
8. Plot the longitudinal profile (**Figure 13**); plot the cross-section locations and the corresponding bankfull elevations on the longitudinal profile (**Figure 13**).
9. Draw a line through the water surface data points of the same bed feature (e.g., top of riffle to top of riffle) to represent the *average water surface slope*. Draw a best-fit line through the bankfull data points (be sure that all bankfull data points are good indicators). Determine the *average water surface slope* and the *bankfull slope*. **Note:** The *average water surface slope* and the *bankfull slope* should be parallel.
10. Enter the *average water surface slope* and *bankfull slope* into appropriate forms (**Worksheet 1**, **Worksheet 2,** and **Worksheet 3**).

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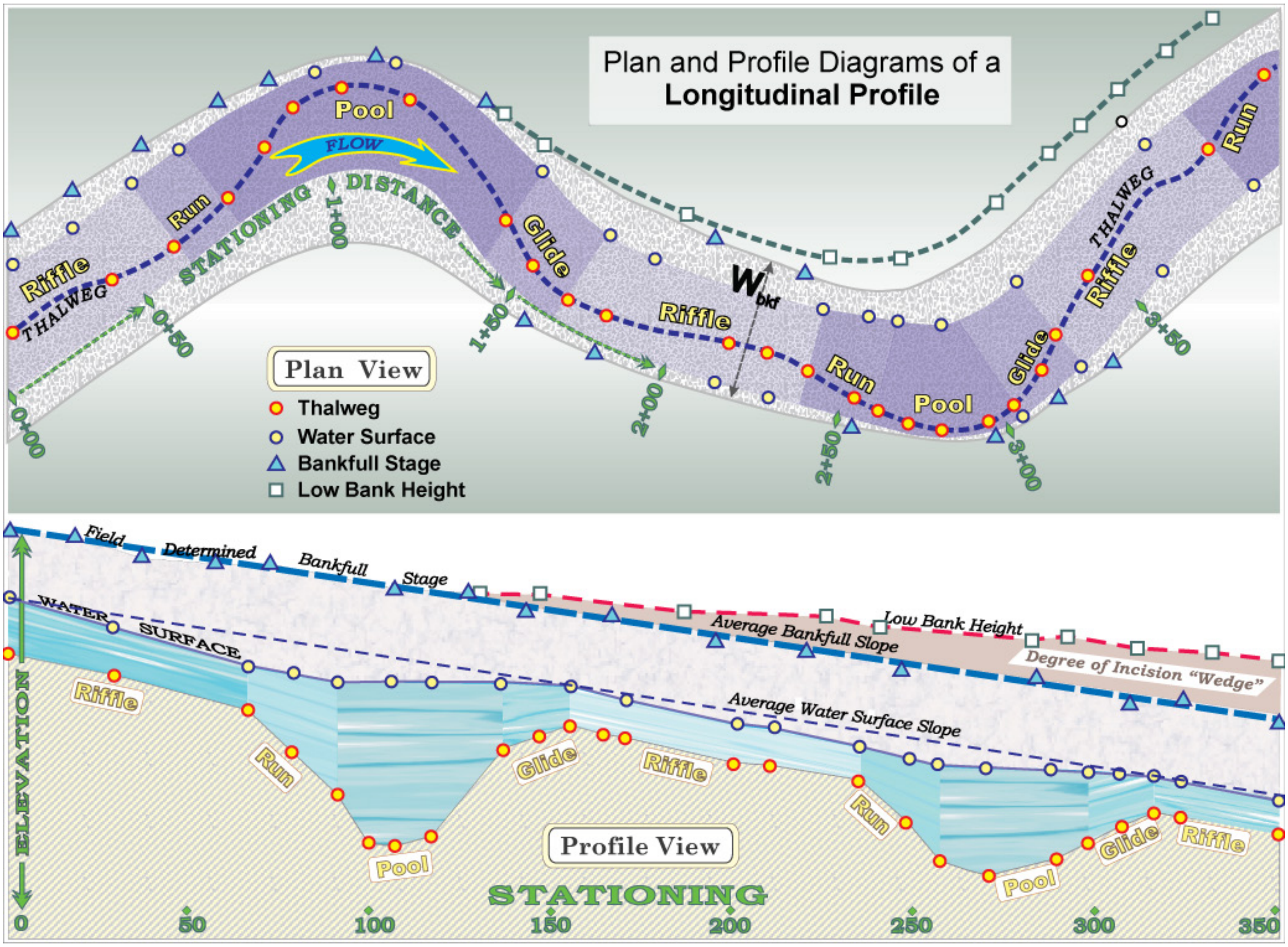

Figure 12. Plan and profile views of a longitudinal profile indicating slope and bed feature measurement locations. **Note:** Stationing distance in this example is measured along right edge of water (REW).

Average Water Surface Slope (*S*): The elevation difference of water surface measurements over the stream length between two similar bed features (e.g., start of riffle to start of last riffle). This value will normally approximate the average bankfull slope.

Average Bankfull Slope (S_{bkf}): The elevation difference of bankfull indicators along the stream length. The elevation differences are obtained from a best-fit line through the bankfull indicators along the longitudinal profile. This slope is generally parallel to the average water surface slope (*S*).

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Table 5. Sample form to record longitudinal profile notes with example data.

SURVEY DATA ⟶ LONGITUDINAL PROFILE 1

SITE: **Raccoon Creek** Date: **3/4/07**

Location: **Reference Reach - Stationing 0+00 thru 3+60**

Observers: **Page 1 of 3** HUC: __ __ __ __ __ __ __ __ __ __ __ __

	Distance, Point, or STATION ft	Back-Sight BS ft	Height of Instru-ment HI ft	Thalweg Fore-Sight FS ft	Thalweg Elevation Elev. ft	Water Surface Fore-Sight FS ft	Water Surface Elevation Elev. ft	Bankfull Fore-Sight FS ft	Bankfull Elevation Elev. ft	Low Bank HI Fore-Sight FS ft	Low Bank HI Elevation Elev. ft	NOTES e.g. Riffle Run Pool Glide
1	**BM1**	**5.28**	**105.28**									
2	**0**			**7.20**	**98.08**	**6.75**	**98.53**					**Riffle**
3	**1**			**7.21**	**98.07**	**6.76**	**98.52**					
4	**17**			**7.28**	**98.00**	**6.89**	**98.39**					
5	**19**			**7.26**	**98.02**	**6.91**	**98.37**	**5.83**	**99.45**			**Run**
6	**25**			**7.65**	**97.63**	**6.99**	**98.29**					
7	**30**			**8.25**	**97.03**	**7.05**	**98.23**					**Pool**
8	**32**			**8.65**	**96.63**	**7.06**	**98.22**					
9	**35**			**8.84**	**96.44**	**7.07**	**98.21**					
10	**46**			**9.03**	**96.25**	**7.08**	**98.20**	**6.05**	**99.23**			
11	**50**			**9.30**	**95.98**	**7.08**	**98.20**					
12	**56**			**9.25**	**96.03**	**7.10**	**98.18**	**5.91**	**99.37**			
13	**69**			**8.55**	**96.73**	**7.10**	**98.18**					
14	**72**			**7.75**	**97.53**	**7.10**	**98.18**					**Glide**
15	**75**			**7.62**	**97.66**	**7.10**	**98.18**	**6.17**	**99.11**			
16	**79**			**7.57**	**97.71**	**7.10**	**98.18**					**Riffle**
17	**90**			**7.60**	**97.68**	**7.15**	**98.13**					
18	**100**			**7.66**	**97.62**	**7.20**	**98.08**					**Run**
19	**105**			**8.12**	**97.16**	**7.28**	**98.00**					**Pool**
20	**112**			**8.91**	**96.37**	**7.30**	**97.98**					
21	**117**			**9.50**	**95.78**	**7.30**	**97.98**					
22	**125**			**8.41**	**96.87**	**7.30**	**97.98**					
23	**129**			**8.80**	**96.48**	**7.30**	**97.98**					**Glide**
24	**135**			**7.70**	**97.58**	**7.31**	**97.97**	**6.25**	**99.03**			**Riffle**
25	**152**			**7.78**	**97.50**	**7.38**	**97.90**					

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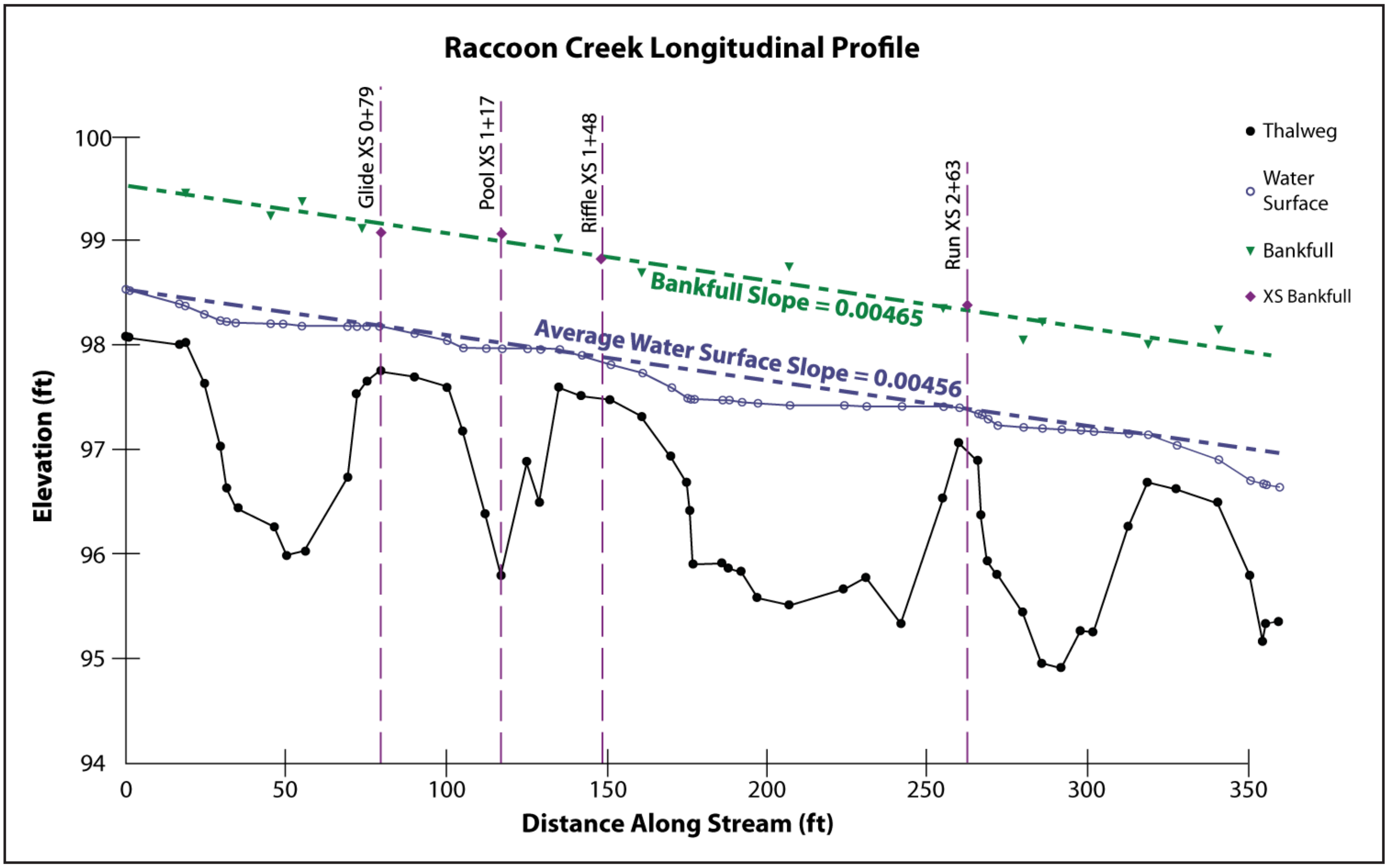

Figure 13. Plotted longitudinal profile (RIVERMorph™).

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Low Bank Height & Degree of Channel Incision

Low Bank Height (LBH) is a feature measured during the longitudinal profile to indicate degree of channel incision (Note: when streams are not incised in any degree, low bank height is equal to the bankfull stage). *Channel incision* is a process relation due to abandonment of an active floodplain and a lowering of local base level. The degree of channel incision is determined by Bank-Height Ratio (BHR) and is calculated by dividing the Lowest Bank Height (LBH) by the bankfull maximum depth (**Figure 14**).

Some rivers may be entrenched (vertical containment of floods); others may have a BHR indicative of a stream that is lowering its local base level but is not yet entrenched. **Figure 14** indicates varying degrees of incision according to BHR values. Streams with high BHR values generally contribute disproportionate amounts of sediment from streambanks and channel beds due to high shear stress. **Worksheet 4** depicts the relation of BHR values to stability risk. For actively incising channels, field-tested regional hydrology curves are often used to obtain bankfull discharge and cross-sectional area by drainage area. This assists in obtaining bankfull maximum depth in such channels where depositional surfaces are not present.

Figure 15 and **Figure 16** illustrate two examples of Bank-Height Ratio values converted to a stream stability rating to indicate degree of incision. These ratings are used in channel assessment.

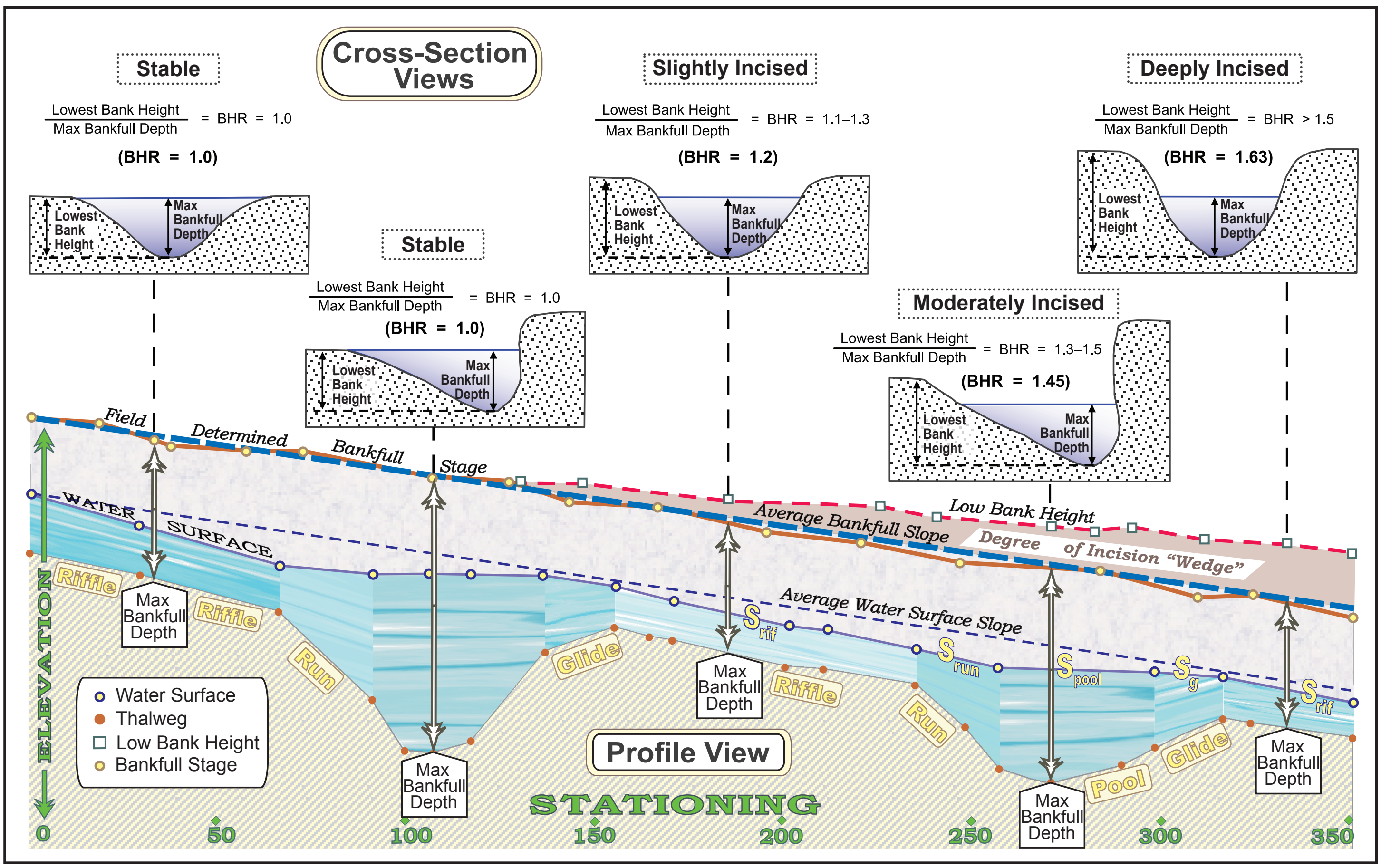

Figure 14. Cross-section views in relation to longitudinal profile depicting various Bank-Height Ratios (BHR) and degree of channel incision ratings.

Worksheet 4. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.

Degree of Channel Incision

Low Bank Height:	
Max Bankfull Depth:	

Bank-Height Ratio:	

Degree of Channel Incision Stability Rating ☛	

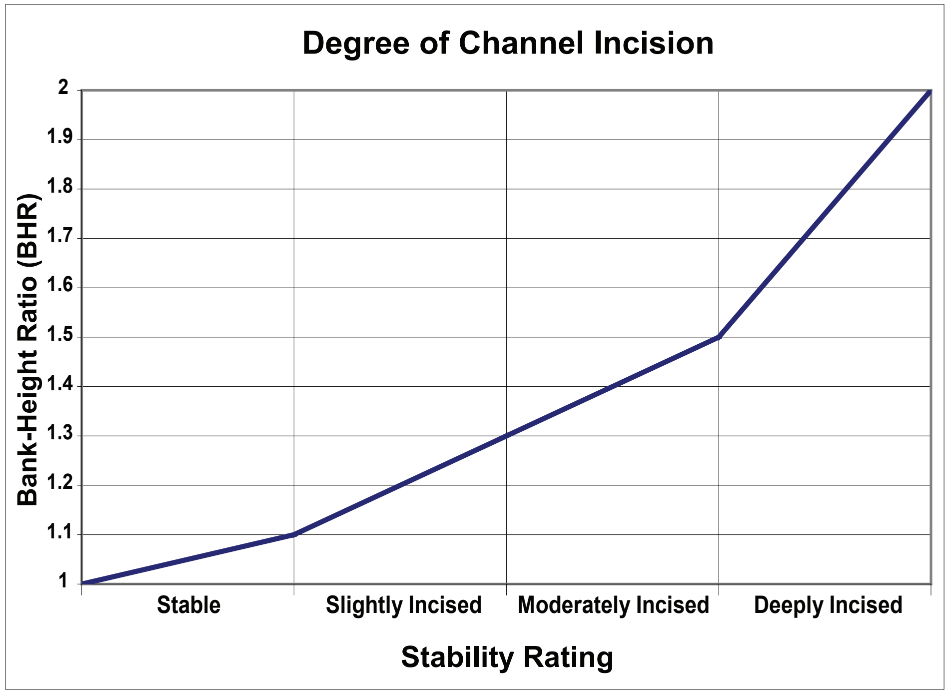

Figure 15. Bank-Height Ratio (BHR) = 1.0 (Stable).

Figure 16. Bank-Height Ratio (BHR) = 1.4 (Moderately Incised).

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SURVEY DATA → LONGITUDINAL PROFILE 1

SITE: Date:

Location:

Observers: HUC: __ __ __ __ __ __ __ __ __ __ __ __

	Distance, Point, or STATION	Back-Sight B S	Height of Instru-ment H I	Thalweg Fore-Sight F S	Thalweg Elevation Elev.	Water Surface Fore-Sight F S	Water Surface Elevation Elev.	Bankfull Fore-Sight F S	Bankfull Elevation Elev.	Low Bank HI Fore-Sight F S	Low Bank HI Elevation Elev.	NOTES e.g. Riffle Run Pool Glide
	ft	ft	ft	ft	ft	ft	ft	ft	ft	ft	ft	
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SURVEY DATA ⟹ LONGITUDINAL PROFILE 2

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Observers: HUC: __ __ __ __ __ __ __ __ __ __ __ __

	Distance, Point, or STATION	Back-Sight B S	Height of Instru-ment H I	Thalweg Fore-Sight F S	Thalweg Elevation Elev.	Water Surface Fore-Sight F S	Water Surface Elevation Elev.	Bankfull Fore-Sight F S	Bankfull Elevation Elev.	Low Bank HI Fore-Sight F S	Low Bank HI Elevation Elev.	NOTES e.g. Riffle Run Pool Glide
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SURVEY DATA ⟹ LONGITUDINAL PROFILE 1

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Location:

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	Distance, Point, or STATION	Back-Sight B S	Height of Instru-ment H I	Thalweg		Water Surface		Bankfull		Low Bank HI		NOTES e.g. Riffle Run Pool Glide
				Fore-Sight F S	Elevation Elev.	Fore-Sight F S	Elevation Elev.	Fore-Sight F S	Elevation Elev.	Fore-Sight F S	Elevation Elev.	
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SURVEY DATA ⟹ LONGITUDINAL PROFILE 2

SITE: Date:

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Party / Notes: HUC: __ __ __ __ __ __ __ __ __ __ __ __

	Distance, Point, or STATION	Back-Sight BS	Height of Instru-ment HI	Thalweg Fore-Sight FS	Thalweg Elevation Elev.	Water Surface Fore-Sight FS	Water Surface Elevation Elev.	Bankfull Fore-Sight FS	Bankfull Elevation Elev.	Low Bank HI Fore-Sight FS	Low Bank HI Elevation Elev.	NOTES e.g. Riffle Run Pool Glide
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